UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

SOME FACTORS AFFECTING THE QUALITY OF RIPE OLIVES STERILIZED AT HIGH TEMPERATURES

BY
W. V. CRUESS

BULLETIN No. 333
OCTOBER, 1921

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY
1921

DAVID P. BARROWS, President of the University.

EXPERIMENT STATION STAFF

HEADS OF DIVISIONS

THOMAS FORSYTH HUNT, Dean.
EDWARD J. WICKSON, Horticulture (Emeritus).
——— ———, Director of Resident Instruction.
C. M. HARING, Veterinary Science, Director of Agricultural Experiment Station.
B. H. CROCHERON, Director of Agricultural Extension.
HUBERT E. VAN NORMAN, Dairy Management.
JAMES T. BARRETT, Plant Pathology; Acting Director of Citrus Experiment Station
WILLIAM A. SETCHELL, Botany.
MYER E. JAFFA, Nutrition.
RALPH E. SMITH, Plant Pathology.
JOHN W. GILMORE, Agronomy.
CHARLES F. SHAW, Soil Technology.
JOHN W. GREGG, Landscape Gardening and Floriculture.
FREDERIC T. BIOLETTI, Viticulture and Fruit Products.
WARREN T. CLARKE, Agricultural Extension.
ERNEST B. BABCOCK, Genetics.
GORDON H. TRUE, Animal Husbandry.
WALTER MULFORD, Forestry.
FRITZ W. WOLL, Animal Nutrition.
W. P. KELLEY, Agricultural Chemistry.
H. J. QUAYLE, Entomology.
ELWOOD MEAD, Rural Institutions.
H. S. REED, Plant Physiology.
L. D. BATCHELOR, Orchard Management.
J. C. WHITTEN, Pomology.
†FRANK ADAMS, Irrigation Investigations.
C. L. ROADHOUSE, Dairy Industry.
R. L. ADAMS, Farm Management.
W. B. HERMS, Entomology and Parasitology.
F. L. GRIFFIN, Agricultural Education.
JOHN E. DOUGHERTY, Poultry Husbandry.
D. R. HOAGLAND, Plant Nutrition.
G. H. HART, Agricultural Engineering.
L. J. FLETCHER, Agricultural Engineering.
EDWIN C. VOORHIES, Assistant to the Dean.

DIVISION OF VITICULTURE AND FRUIT PRODUCTS

FREDERIC T. BIOLETTI
L. O. BONNETT
G. BAROVETTO
W. V. CRUESS
A. W. CHRISTIE
J. H. IRISH

† In coöperation with Office of Public Roads and Rural Engineering, U. S. Department of Agriculture.

SOME FACTORS AFFECTING THE QUALITY OF RIPE OLIVES STERILIZED AT HIGH TEMPERATURES

By W. V. CRUESS

CONTENTS

The California State Board of Health ruled in August, 1920, that pickled ripe olives which are to be offered for sale must be sterilized at 240° F. for 40 minutes in steam pressure retorts equipped with accurate recording thermometers. This regulation was based on the results of investigations upon the death temperature of *Bacillus botulinus* conducted by Dr. E. C. Dickson, of the Stanford University Medical School, and Dr. K. F. Meyer, of the University of California.

During the season of 1919 experiments by the writer demonstrated that sterilization of olives at 240° F. to 250° F. resulted in many cases in softening and in severe injury to the flavor, and at the beginning of the 1920–21 olive canning season, when the regulation of the State Board of Health was for the first time put into general effect, it was found that much of the fruit softened and acquired a disagreeable "scorched" flavor. In some instances both defects developed, in others only the scorched flavor. Olives from different factories and from different pickling vats in the same factory varied greatly in their behavior.

The investigations reported in this bulletin were undertaken in an attempt to determine the causes of the observed differences, and have extended over two canning seasons.

Variety.—Pickled Mission, Manzanillo, Sevillano, and Ascolano, from a single factory, were canned and sterilized at 240° F. for 40 minutes. Several lots of Mission and Manzanillo olives were pickled in the laboratory and were sterilized in the same way. The flavor and texture of the different varieties were compared immediately after canning, one month later, and six months later. Numerous samples of Mission, Manzanillo, and Sevillano olives canned on a commercial scale and sterilized at 240° F. for 40 minutes have also been examined and compared.

As a result of these comparisons, it was found that the Manzanillo variety was more sensitive to high temperatures than any of the other varieties named. The Sevillano variety was remarkably resistant and in many instances was improved in flavor by sterilization at 240° F. The Mission variety, when properly pickled, suffered very little in quality from the high temperature. All varieties, however, varied greatly in their behavior according to the treatment given before canning.

Maturity.—Manzanillo olives deteriorated in flavor and texture at 240° F. very much more when perfectly ripe than when unripe. Mission olives showed less difference in this respect.

No data were obtained on the effect of maturity of Ascolano and Mission olives on their behavior at high temperatures. These varieties are normally gathered for pickling before they are fully mature.

Holding Solutions.—Olives are often held in brine or water for several weeks before they are pickled. They are usually shipped in barrels or tank cars, in dilute brine, from the orchard to the factory. Laboratory experiments and factory observations have proved that olives stored in water frequently become slimy and undergo bacterial decomposition. Microscopic examination of olives stored in water for about three weeks in three factories demonstrated the presence of mold filaments and motile bacteria in the olive flesh and a slimy growth of mold and yeastlike organisms on the surface of the fruit. Some of the fruit in these three lots had undergone visible decomposition. Unless the storage in water is for a short period only (a week or less) or the water is changed frequently, the use of water for the storage of olives is not advisable.

In practically all factories, brines are now used as holding solutions. There is great variation, however, in the strength of these brines. Analyses have shown concentrations varying from 1.2 per cent to 10 per cent salt, the average being approximately 3 per cent. The density of these solutions averaged approximately 1° Baume above the percentage of the salt determined by chemical analysis. The olives

in a 10 per cent brine (40° salometer test) gave no evidence of mold growth or of fermentation. Those in very dilute brines in some instances exhibited vigorous mold growth, active fermentation, and some softening of the flesh. Although fermentation and formation of acid occurred in olives in brines of 4 to 6 per cent salt (16 to 24° salometer), the olives did not have a disagreeable odor and had become considerably firmer than when first placed in the brine. It is probable that the lactic acid formed in such brines retards the growth of undesirable organisms, such as *Bacillus botulinus,* but the use of a brine of 10 per cent salt (40° salometer) is undoubtedly more effective. If very strong brines are used, it is necessary to increase the salt concentration gradually and progressively in order to avoid shrivelling of the fruit. On this account, it is not convenient to use a 10 per cent brine for shipping unpickled olives. A 5 per cent brine may be used for this purpose, however, and more salt may be added after the arrival of the fruit at the factory. The brine should be leached from the fruit by soaking the fruit in water before it is pickled.

Experiments and experience have proved that storage of soft and over-ripe olives in brine makes them firmer and of more uniform quality after pickling. Whether prime ripe, sound, and firm olives are improved by storage in brine before pickling is an open question.

Lye Treatment.—In order to determine the relation of the thoroughness of the lye treatment to the flavor and texture of olives sterilized at 240° F., a number of samples representing different pickling processes and the different stages of the pickling process were canned and sterilized at 240° F. for 40 minutes. Some of these samples were canned in commercial olive packing plants and others were pickled and canned in the laboratory. The experiments are summarized in the following list.

List of Experiments Conducted to Determine the Relation of Lye Treatment to Quality of Olives Sterilized at 240° F. for 40 Minutes

Character of sample	Result
1. Unpickled olives direct from tree (Mission, Manzanillo, Sevillano, Ascolano varieties).	Badly softened.
2. Unpickled Mission olives after three weeks in holding brine.	About 75 per cent of fruit softened. Remainder firm.
3. Mission and Manzanillo olives containing small excess of lye from final lye treatment. Five samples of each variety.	Very pronounced scorched flavor. About 25 per cent of fruit badly softened.

Character of sample	Result
4. Mission, Manzanillo, and Sevillano olives pickled and sorted out as "bitters" at cannery table. Contained considerable bitter flesh at blossom end of fruit. Several samples of each variety.	Pronounced scorced flavor. From 25–75 per cent of fruit soft and "mushy" at blossom end.
5. Pickled Manzanillo olives containing considerable bitterness. These came from a factory that canned olives with this degree of bitterness.	Pronounced scorced flavor and 10–25 per cent of fruit badly softened.
6. Olives of same lot as No. 5 treated in laboratory with 1 per cent lye to pit. Canned after removal of lye by leaching.	No softening. Very faint scorched flavor. Color somewhat lighter than sample No. 5 but still satisfactory.
7. Slightly bitter pickled Mission olives from three factories, canned in laboratory. Representative of usual pack of these factories.	Pronounced bitter almond odor and scorched flavor. Five to 10 per cent of fruit softened at blossom end of fruit.
8. Same as No. 7, but treated to pit with 1 per cent lye. Lye leached from fruit with water before canning.	No bitter almond odor or scorched flavor. No softening. Color not quite so dark as in No. 7.

From these experiments it was concluded that the development of scorched flavor, bitter almond odor, and excessive softening of the fruit observed in several factories during sterilization was due, at least in part, to insufficient lye treatment or to the presence in the fruit of excess lye. The experiments proved that slightly bitter pickled olives can be treated with a dilute lye solution to remove all trace of bitterness, and be canned with good results after the lye has been removed by leaching with water. Too prolonged treatment or too strong lye results in softening and loss of color.

A convenient method of detecting very bitter olives in more perfectly pickled fruit consisted in heating the olives in brine and boiling for about twenty minutes. Very bitter fruit softened and could then be easily detected and removed at the sorting tables. It is possible, however, to treat the olives so thoroughly with lye that no bitter fruit will be found.

Bacterial Action.—Fruit softened, injured in flavor, or otherwise damaged by bacterial growth in the fruit before pickling, was not improved by sterilization at 240° F. Unpickled fruit which had been fermented in holding solutions without softening, remained firm after sterilization.

Excessive bacterial growth in the fruit during pickling and during the following storage in brine resulted in softening of a large proportion and in injury to the flavor. Fermentation of the pickled fruit before canning caused the color to become lighter and formed "gas pockets" in the flesh which collapsed during sterilization, giving a pitted appearance to the fruit.

By the use of holding solutions of sufficient strength for fresh fruit and by not permitting the pickled olives to remain too long in dilute brine before canning, the above defects may be avoided.

Salt Concentration.—Increase of the strength of the brine used in canning reduced the tendency of the olives to soften, but the use of concentrations above 4 per cent salt (16° salometer) rendered the fruit too salty in flavor. Better results were obtained by placing the pickled fruit in a brine of 8 per cent to 9 per cent (32°–36° salometer) for four to six days and canning the fruit in water. Although shrivelled in appearance and very salty in flavor at the time of canning, the olives became plump and not too salty in flavor after canning.

Gradual increase of the brine from 6 per cent to 7 per cent (24° to 28° salometer) after pickling, followed by canning in a 2½ to 2 per cent brine (8° to 10° salometer), caused the olives to be firmer than if canned directly from the storage in 2½ or 3 per cent brine.

As olives decrease in size when stored in strong brines and increase in size when transferred to water or dilute brine, less fruit than would otherwise be necessary is required to give a well filled can.

Increase of Acidity of Brine.—It has been proved by Dr. E. C. Dickson,[1] of Stanford, by the writer,[2] and more recently confirmed by Weiss,[3] that the spores of heat-resistant bacteria are more easily killed by heat in an acid solution than in a neutral one. Pickled ripe olives and the brine in which they are canned are practically neutral.

During both the 1919 and 1920 seasons, ripe pickled olives of the Mission and Manzanillo varieties were stored in brines acidified to various degrees with citric, acetic, and lactic acids respectively. These olives were in some instances canned in the brine in which they were stored and in others in freshly prepared non-acidified brines. Some cans were sterilized at 240° F. for 40 minutes and others at 212° F. for 60 minutes.

---

[1] E. C. Dickson. Botulism. Reprint from the Canadian Medical Journal, October, 1918, p. 5.

[2] W. V. Cruess. Home Canning of Fruits and Vegetables. Circular 158, University of California Experiment Station, 1915, p. 4.

[3] H. Weiss. "The Heat Resistance of Spores with Special Reference to B. botulinus." Journal of Infectious Diseases, 1921, pp. 70–92.

Formation of hydrogen gas and swelling of the cans occurred with citric acid when the acidity of the brine in which the olives were soaked exceeded .3 per cent. Brines of .25 per cent or less did not cause swelling of the cans. The formation of the gas resulted from the action of the acid on the tin plate. There was no evidence of bacterial growth in any of the samples canned (approximately 300 cans).

The acidity of the brine was much less after canning than when placed upon the olives. This reduction in acidity was probably due in part to absorption of acid by the fruit and in part to neutralization of a part of the acid by basic salts in the fruit. Brines which originally contained .3 per cent citric acid contained from .1 per cent to .14 per cent after canning.

The olives soaked in brine of .3 per cent citric acid were decidedly "tart" in flavor, very much toughened in texture, and considerably bleached in color. They were not of satisfactory quality. Brines of .2 per cent citric acid gave a product of pleasing flavor, but of somewhat lighter color and of tougher texture than the untreated samples.

Acetic acid imparted a disagreeable odor and flavor to the olives. Lactic acid gave results similar to citric acid.

Acidification of the brines is not recommended, because it causes more serious changes in the quality of the fruit than occur through sterilization of the non-acidified pickled fruit at 240° F. for 40 minutes.

Temperature.—Olives of the Mission, Manzanillo, and Sevillano varieties were canned experimentally and heated to temperatures ranging from 190° F. to 250° F., and for lengths of time varying from 15 to 60 minutes at the higher temperatures and from 20 to 120 minutes at 212° F. Numerous samples of these varieties canned commercially in 1919 and 1920 in olive factories, were also compared. These commercial samples represented processing temperatures of 190° F. to 250° F.

In one test, Mission olives of large size, black color, and free from bitterness, were canned and heated as follows:

212° F.,			45,	and	120	minutes.
220° F.,	15,	30,		and	60	minutes.
225° F.,	15,	30,		and	60	minutes.
230° F.,	15,	30,	40,	and	60	minutes.
235° F.,	15,	30,	40,	and	60	minutes.
240° F.,	15,	30,	40,	and	60	minutes.
250° F.,	15,	30,	40,	and	60	minutes.

The olives were canned in six-ounce plain tin cans and were not cooled in water after heating.

About 10 per cent of the fruit softened excessively when heated to 250° F. for 40 and 60 minutes, and to 240° F. for 60 minutes. A sample heated to 260° F. for 60 minutes was still edible, but badly softened. The olives heated to 250° F. for 15, 30, 40, and 60 minutes

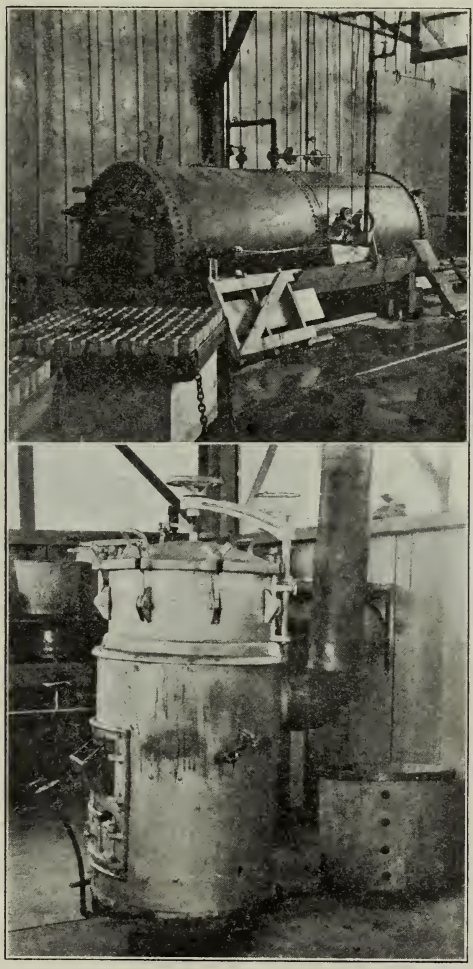

Fig. 1.—Upper view: Large horizontal steam pressure retort with recording thermometer. Used for olive sterilization. Lower view: Small steam pressure retort suitable for the small scale olive canner.

and to 240° F. for 30, 40, and 60 minutes had a marked scorched flavor. Those heated to 240° F. for 15 minutes, 235 F. for 40 and 60 minutes, and to 220° F. for 60 minutes were of noticeable but not marked scorched flavor. The scorched flavor was not evident in other

samples of this series. After one month's storage, the scorched flavor had very greatly diminished in all samples. After six months' storage, most of the scorched flavor had disappeared. The samples were again examined at the end of eighteen months, and it was found that the fruit heated to 250° F. and 240° F. had still further improved in flavor. The olives sterilized at 250° F. and 240° F. for 40 and 60 minutes were lighter in color immediately after heating than those less severely heated. After six and eighteen months' storage, respectively, there was very little difference in color; but the olives heated to 250° F. and to 240° F. were in most samples a little darker than those heated to 212° F.

As stated elsewhere in this publication (see Lye Treatment, page 223), the presence in the olives of flesh which had not been penetrated by lye, resulted in the development at 240° F. of a very pronounced scorched flavor, and in softening of the fruit. This was true particularly of the Manzanillo variety. Many of the commercially canned olives sterilized at 240° F. for 40 minutes during the 1920 season appeared to be badly damaged in flavor. However, at the present time (July, 1921) this fruit has "recovered" in flavor and is, on the average, of very good quality. The Sevillano variety has suffered least and the Manzanillo most by sterilization at 240° F. in the factories in the state. The Mission variety occupies an intermediate position.

That properly pickled olives sterilized at 240° F. for 40 minutes are acceptable to the average consumer has been demonstrated on a number of occasions by asking classes of students and other groups of people to compare the flavor of olives heated in this manner with those heated to 212° F. In many instances, the olives sterilized at 240° F. were preferred, because of their more distinctive flavor.

It is therefore permissible to conclude that pickled ripe olives may be sterilized at 240° F. for 40 minutes, according to the regulation of the State Board of Health, without serious damage to the quality of the product.

Rapid chilling of the can and contents to room temperature immediately after sterilizing is desirable in order to prevent prolonged action of the heat.

Investigations in 1919 by De Bord, Edmonson, and Thom, of the U. S. Department of Agriculture,[4] indicated that many canned olives on the market at that time were not sterile; but, in the investigations reported, no data are given on the relation between sterility and the

[4] G. G. De Bord, R. B. Edmonson, C. Thom, Journal American Medical Association, vol. 74, pp. 1220–1221 (May 1, 1920).

temperature employed in canning. H. K. Beresford[5] found that nearly all samples heated to 190° F. and 212° F. examined by him were not sterile; that of those heated to 220, 225, and 230° F. for 20 to 30 minutes, about 15 per cent were not sterile, and of those heated to 240° F. for 30 minutes, and to 250° F. for 15 minutes, all were sterile. The experiments were not sufficiently extensive to be conclusive, but the results are of sufficient interest to warrant publication.

Fig. 2.—Pickling vats in a California factory.

Character of Container.—Olives canned in 1915 in enameled lined cans had retained their color much more satisfactorily, after one year's storage, than olives from the same lot in plain tin cans. The brine was clearer but darker in color in the lacquered cans. No difference was noted in flavor. Several of the cans of both kinds were recently opened (six years after canning) and the differences noted above had become even more striking.

The experiments were repeated in 1920 with six lots of olives representing both Mission and Manzanillo. Six months after sterilization at 240° F. for 40 minutes, the olives in lacquered cans were noticeably darker in color than those in tin cans. Apparently, the action of the brine or of fruit compounds upon the tin plate results in the formation of sufficient hydrogen to cause bleaching of the olives. The bleaching action is temporary, as is proved by the fact that the olives from the plain tin cans regained much of their original color when exposed to the air for 24 hours.

[5] Formerly a student in the University.

Olives in glass jars sterilized at 240° F. for 40 minutes developed a pitted appearance when the jars were opened later. This may possibly be explained as follows: The caps of these jars do not prevent the escape of gases or steam under heavy pressure. Consequently, as, after the steam pressure in the sterilizer is cut off, the jars and olives remain for a short time at a temperature above that of the space in the sterilizer surrounding the jars, steam is formed in the jars and escapes between the jar and the cap, which acts as a valve. Steam is probably generated violently in the olive flesh and ruptures it, forming "pockets." These "pockets" are plainly visible when such olives are cut to the pit. As the jars cool, the caps become cemented to the glass and form an air-tight seal. As cooling continues, a vacuum is formed in the jar and under its action, the olives become plump in spite of the presence of the "pockets" in their flesh. When such a jar is opened, however, the vacuum is released and the fruit is subjected to atmospheric pressure which causes depressions where the "pockets" exist. Olives sterilized at 240° F. in open cans, or cans in the tops of which small holes are made, develop the pitted appearance noted above. Those in perfectly sealed cans do not exhibit this phenomenon.

The use of air under high pressure with the steam in the sterilization of olives in glass jars has overcome the difficulty in one factory, although rapid circulation of the air and steam in the retort is necessary to insure a uniform temperature throughout. Circulation is attained by use of open petcocks on the retort.

Gallon cans and cans of other large sizes frequently become "buckled" or in some instances open at the top and bottom seams unless cooled under air pressure in the retorts. The tendency to "buckle" was greatly reduced when the cans and olives were thoroughly heated in the exhaust box to 195° F. before sealing.

SUMMARY AND CONCLUSIONS

1. Properly pickled olives yield an acceptable product when sterilized at 240° F. for 40 minutes.

2. The Manzanillo olive is more subject to damage in flavor and texture at 240° F. than the Mission, Sevillano, and Ascolano varieties.

3. Very ripe olives are more liable to damage at 240° F. than less mature fruit. Manzanillo olives, particularly, should not be too ripe when pickled.

4. Brines of sufficient strength to prevent decomposition of the olives should be used for holding solutions. Brine of 5 per cent salt (20° salometer) is recommended for shipment of olives, and one of 10 per cent salt (40° salometer) for holding olives in the factory for long periods.

5. Lye treatment must be thorough and all bitterness removed if the best flavor and texture are to be obtained in olives sterilized at 240° F.

6. Fermentation and bacterial action in the pickled fruit causes "floaters" and pitting of the fruit. Long storage of pickled fruit in dilute brine should therefore be avoided.

7. Storage of the fruit in strong brine for several days followed by canning in very dilute brine or water makes the texture of the fruit firmer.

8. Acidified brines act vigorously upon the tin plate and impart an undesirable flavor to the fruit.

9. Olives retain their color more satisfactorily in lacquered than in plain cans.

10. The scorched flavor noted in most olives immediately after sterilization at 240° F. rapidly diminishes during storage.

STATION PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION

BULLETINS

No.
185. Report of Progress in Cereal Investigations.
231. Walnut Culture in California.
241. Vine Pruning in California, Part I.
246. Vine Pruning in California, Part II.
251. Utilization of the Nitrogen and Organic Matter in Septic and Imhoff Tank Sludges.
253. Irrigation and Soil Conditions in the Sierra Nevada Foothills, California.
261. Melaxuma of the Walnut, "Juglans regia."
262. Citrus Diseases of Florida and Cuba Compared with Those of California.
263. Size Grades for Ripe Olives.
266. A Spotting of Citrus Fruits Due to the Action of Oil Liberated from the Rind.
267. Experiments with Stocks for Citrus.
268. Growing and Grafting Olive Seedlings.
270. A Comparison of Annual Cropping, Biennial Cropping, and Green Manures on the Yield of Wheat.
271. Feeding Dairy Calves in California.
272. Commercial Fertilizers.
273. Preliminary Report on Kearney Vineyard Experimental Drain.
274. The Common Honey Bee as an Agent in Prune Pollination.
275. The Cultivation of Belladonna in California.
276. The Pomegranate.
278. Grain Sorghums.
279. Irrigation of Rice in California.
280. Irrigation of Alfalfa in the Sacramento Valley.
282. Trials with California Silage Crops for Dairy Cows.
283. The Olive Insects of California.
285. The Milk Goat in California.
286. Commercial Fertilizers.
288. Potash from Tule and the Fertilizer Value of Certain Marsh Plants.
290. The June Drop of Washington Navel Oranges.
294. Bean Culture in California.
297. The Almond in California.
298. Seedless Raisin Grapes.
299. The Use of Lumber on California Farms.
300. Commercial Fertilizers.
301. California State Dairy Cow Competition, 1916-1918.
302. Control of Ground Squirrels by the Fumigation Method.
303. Grape Syrup.
304. A Study on the Effects of Freezes on Citrus in California.
308. I. Fumigation with Liquid Hydrocyanic Acid. II. Physical and Chemical Properties of Liquid Hydrocyanic Acid.
309. I. The Carob in California. II. Nutritive Value of the Carob Bean.
310. Plum Pollination.
311. Investigations with Milking Machines.
312. Mariout Barley.
313. Pruning Young Deciduous Fruit Trees.
316. The Kaki or Oriental Persimmon.
317. Selections of Stocks in Citrus Propagation.
318. The Effects of Alkali on Citrus Trees.
319. Caprifigs and Caprification.
320. Control of the Coyote in California.
321. Commercial Production of Grape Syrup.
322. The Evaporation of Grapes.
323. Heavy vs. Light Grain Feeding for Dairy Cows.
324. Storage of Perishable Fruit at Freezing Temperatures.
325. Rice Irrigation Measurements and Experiments in Sacramento Valley, 1914-1919.
326. Brown Rot of Apricots.
327. Commercial Fertilizers.
328. Prune Growing in California.
329. A White Fir Volume Table.
330. Dehydration of Fruits.
331. Phylloxera-Resistant Stocks.
332. Walnut Culture in California.
333. Some Factors Affecting the Quality of Ripe Olives Sterilized at High Temperatures.

CIRCULARS

No.
70. Observations on the Status of Corn Growing in California.
76. Hot Room Callusing.
82. The Common Ground Squirrels of California.
87. Alfalfa.
110. Green Manuring in California.
111. The Use of Lime and Gypsum on California Soils.
113. Correspondence Courses in Agriculture.
114. Increasing the Duty of Water.
115. Grafting Vinifera Vineyards.
117. The Selection and Cost of a Small Pumping Plant.
126. Spraying for the Grape Leaf Hopper.
127. House Fumigation.
128. Insecticide Formulas.
129. The Control of Citrus Insects.
130. Cabbage Growing in California.
131. Spraying for Control of Walnut Aphis.
135. Official Tests of Dairy Cows.
137. Wood Decay in Orchard Trees.
138. The Silo in California Agriculture.
139. The Generation of Hydrocyanic Acid Gas in Fumigation by Portable Machines.
144. Oidium or Powdery Mildew of the Vine.
148. "Lungworms."
151. Feeding and Management of Hogs.
152. Some Observations on the Bulk Handling of Grain in California.
153. Announcement of the California State Dairy Cow Competition, 1916-18.
154. Irrigation Practice in Growing Small Fruits in California.
155. Bovine Tuberculosis.
157. Control of the Pear Scab.
158. Home and Farm Canning.
159. Agriculture in the Imperial Valley.
160. Lettuce Growing in California.
161. Potatoes in California.
164. Small Fruit Culture in California.
165. Fundamentals of Sugar Beet Culture under California Conditions.
166. The County Farm Bureau.
167. Feeding Stuffs of Minor Importance.
168. Spraying for the Control of Wild Morning-Glory within the Fog Belt.
169. The 1918 Grain Crop.
170. Fertilizing California Soils for the 1918 Crop.
172. Wheat Culture.
173. The Construction of the Wood-Hoop Silo.
174. Farm Drainage Methods.
175. Progress Report on the Marketing and Distribution of Milk.
176. Hog Cholera Prevention and the Serum Treatment.
177. Grain Sorghums.
178. The Packing of Apples in California.
179. Factors of Importance in Producing Milk of Low Bacterial Count.
181. Control of the California Ground Squirrel.
182. Extending the Area of Irrigated Wheat in California for 1918.

No.

183. Infectious Abortion in Cows.
184. A Flock of Sheep on the Farm.
185. Beekeeping for the Fruit-grower and Small Rancher or Amateur.
188. Lambing Sheds.
189. Winter Forage Crops.
190. Agriculture Clubs in California.
191. Pruning the Seedless Grapes.
193. A Study of Farm Labor in California.
198. Syrup from Sweet Sorghum.
201. Helpful Hints to Hog Raisers.
202. County Organizations for Rural Fire Control.
203. Peat as a Manure Substitute.
204. Handbook of Plant Diseases and Pest Control.
205. Blackleg.
206. Jack Cheese.
208. Summary of the Annual Reports of the Farm Advisors of California.
209. The Function of the Farm Bureau.

No.

210. Suggestions to the Settler in California.
214. Seed Treatment for the Prevention of Cereal Smuts.
215. Feeding Dairy Cows in California.
217. Methods for Marketing Vegetables in California.
218. Advanced Registry Testing of Dairy Cows.
219. The Present Status of Alkali.
220. Unfermented Fruit Juices.
221. How California is Helping People Own Farms and Rural Homes.
222. Fundamental Principles of Co-operation in Agriculture.
223. The Pear Thrips.
224. Control of the Brown Apricot Scale and the Italian Pear Scale on Deciduous Fruit Trees.
225. Propagation of Vines.
226. Protection of Vineyards from Phylloxera.
227. Plant Disease and Pest Control.